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Utilization of renewable energies in Turkey's agriculture

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ABSTRACT

Agriculture is still the occupation of the majority of Turkish people, despite the share of industry and services rising constantly. In terms of agricultural lands, Turkey is also one of the largest countries in the world. Fruits and field crops make up for the most of vegetable products, wheat being the leading crop. Turkey has a high trade surplus with the EU-27 (1.5 billion Euros in 2009) mainly due to exports of edible fruits and nuts, preparations of fruit and vegetables.

The aim of this study is to investigate the utility of renewable energies for agricultural activities. In this concept, solar energy, biomass energy, wind energy, geothermal energy and hydropower are discussed by application examples performed in Turkey. In conclusion, proposals and recommendations are given as alternative energy instead of fossil energy sources.

Contents

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1. Introduction

Turkey's population is about 65 million and 24 million people of this population are engaged in agriculture. About 55.6% of the country is arable land and 15% consists of forests. Amounts of cereals, vegetables, fruits, some animals and other products are given in Figs. 1–8 [1]. The cultivated land is around 28 million ha. Around 18.4% of the cultivated land is irrigated. Vegetable products account for 76% of total agricultural production, then animal husbandry; meanwhile, forestry and fishing contribute a minimal amount [2]. Fig. 1 shows production amounts of cereals, vegetables and fruits between years 2009 and 2010. Although clearly a little decrease is seen, production rate is still important and efficient.

As it can be seen from Fig. 2, between the years 2005 and 2008, some agricultural products' production rate has decreased. This can be depended on climate change, seeds quality, farmers' financial possibility and also agricultural production policies. Also, some of them had a raise. Especially in sugar beet and corn production, year range, has risen. These products are important in food industry, and also in bioethanol production. In addition to this, Figs. 3 and 4 also

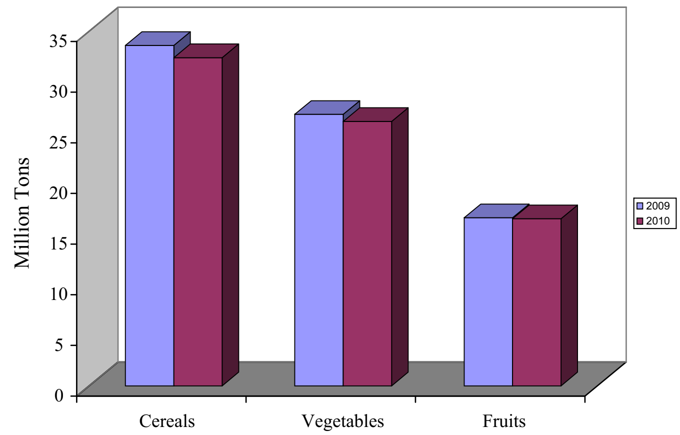

Fig. 1. Amounts of cereals, vegetables and fruits production between 2009 and 2010.

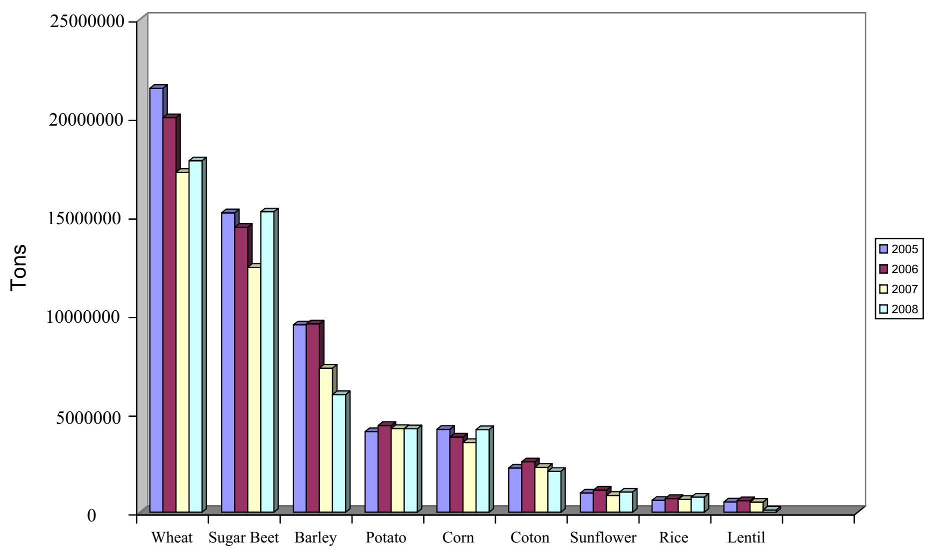

Fig. 2. Amounts of some agricultural products between 2005 and 2008.

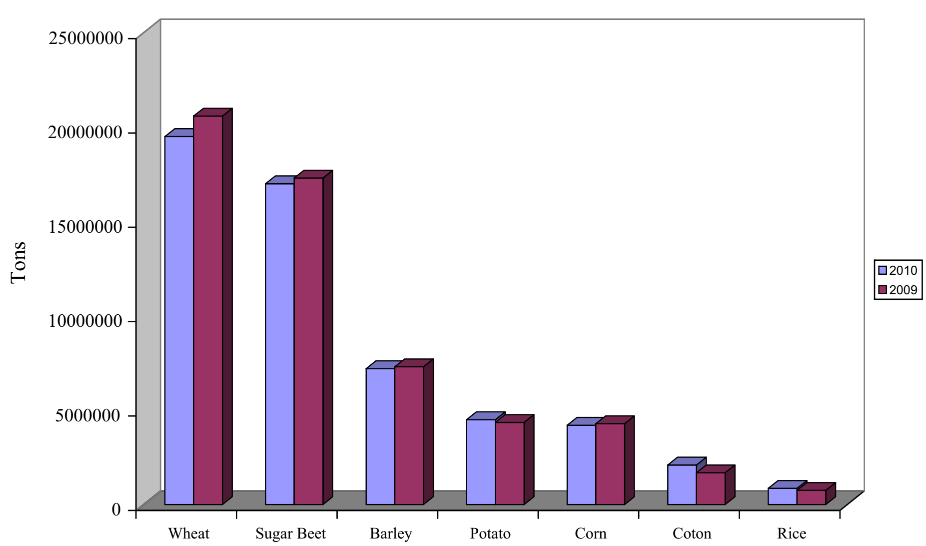

Fig. 3. Amounts of some agricultural products between 2009 and 2010.

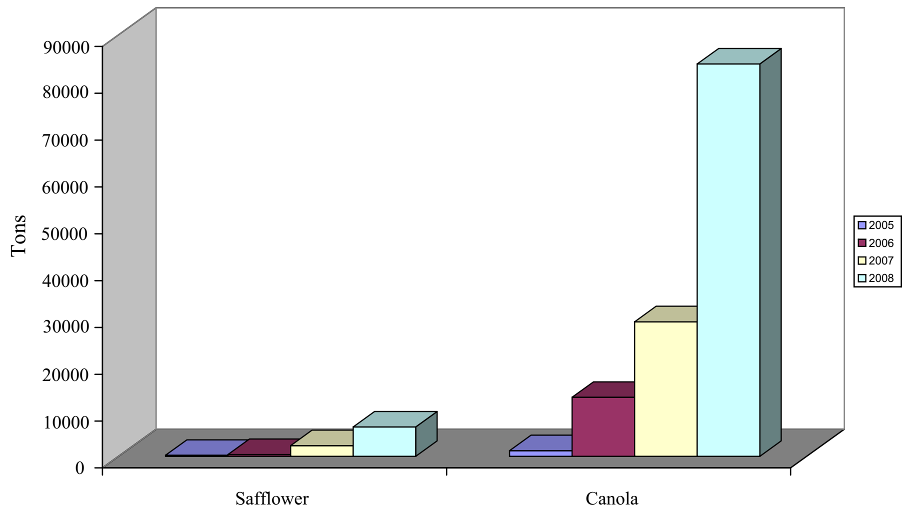

Fig. 4. Amounts of safflower and canola production as energy crops between 2005 and 2008.

show some agricultural amounts between the years 2005–2008 and 2009–2010.

As it can be seen from Figs. 2 and 3, wheat and sugar beet have the biggest share of these figures. Their production amounts have been increasing by the years.

Safflower and canola, which are important as biodiesel's raw material, have increased in 2008 by the development of biodiesel production and been getting popular in Turkey. Fig. 4 shows the increase of safflower and canola production.

Turkey's agricultural products variety is substantial. Fig. 5 shows a little bit part of this variety and those products' production rate between years 2005 and 2008. Grape, olive and hazelnut amounts are remittent and depend on bad harvest conditions.

Turkey's agriculture is embedded with stock farming and considerable amounts of farmer are interested because meat, milk and wool are important to earn money. Number of cattle, sheep and goat between 2008 and 2009 is shown in Fig. 6.

Besides stock farming, barnyard fowl has a considerable amount in agriculture. Especially broiler hen and layer hen are important economically and to provide food requirement. Fig. 7 shows the broiler and layer hen amounts and Fig. 8 shows chicken egg amounts between years 2008 and 2009.

According to 2008 data, energy need for agricultural activities had been calculated to about 422 GWh. These agricultural activities, such as field irrigation, greenhouse/barn/house heating and cooling, food drying, etc. need energy and fossil sources and are mostly used to provide energy requirements. This situation is not sustainable, so it should be thought to use renewable energies in agriculture.

Turkey's primary energy sources are solar, biomass, geothermal, wind energies and hydropower. The share of renewables in total electricity generation is 29.63%, while that of natural gas is 45% [3]. Table 1 shows renewable energy sources, wastes and energy equivalence [4].

The renewables together currently provide 13.2% of the primary energy, mainly in the form of combustible renewables and wastes (6.8%), hydropower (about 4.8%) and other renewable energy resources (about 1.6%). Table 2 shows renewable energy potential in Turkey [5].

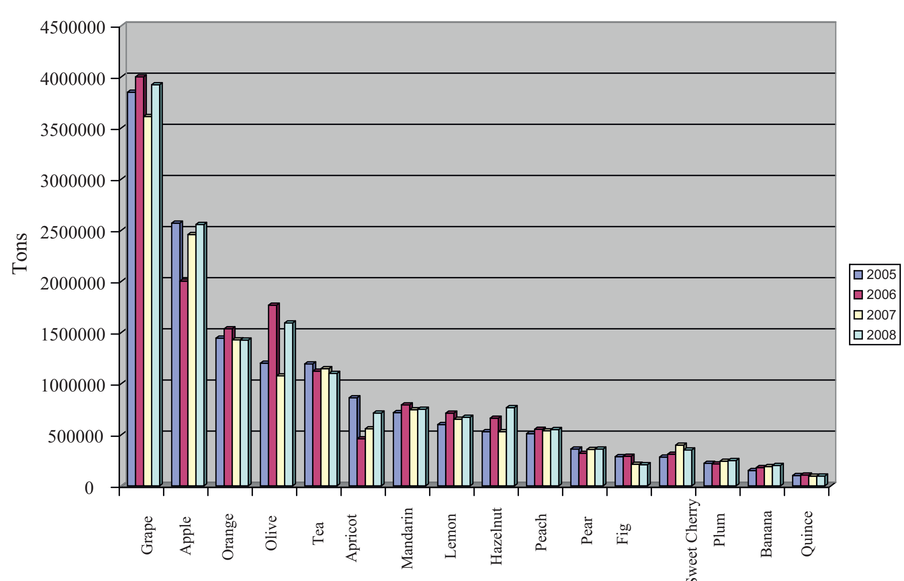

Fig. 5. Amounts of some fruits production between 2005 and 2008.

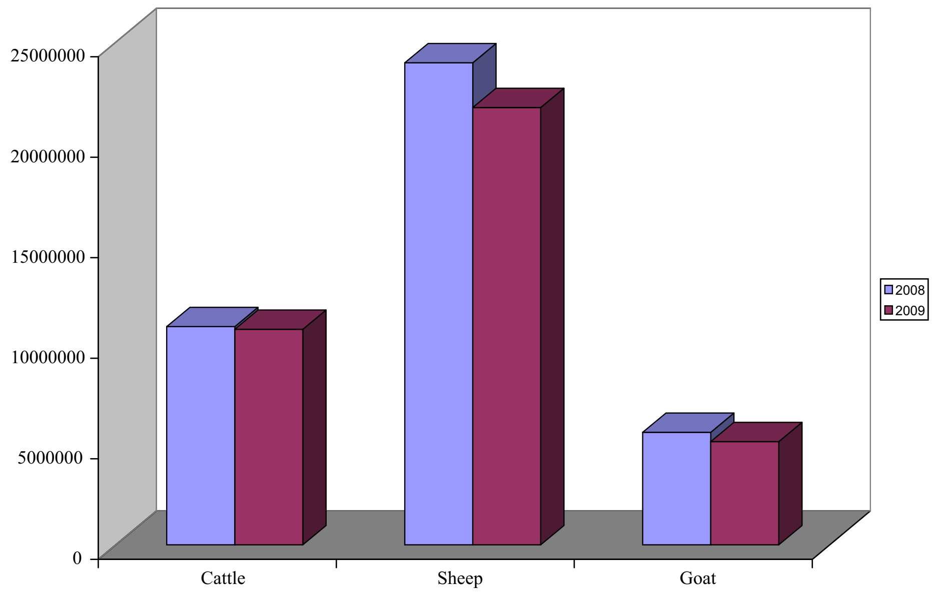

Fig. 6. Number of cattle, sheep and goat between 2008 and 2009.

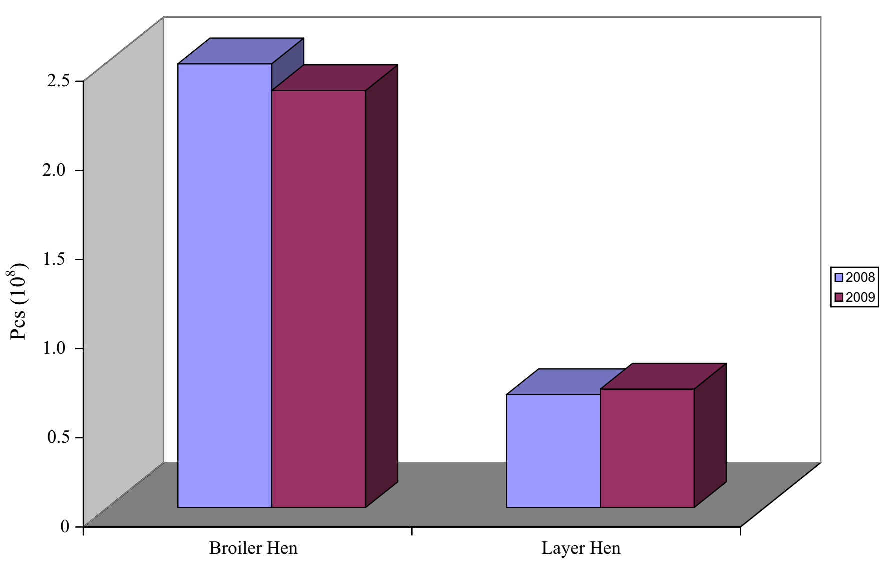

Fig. 7. Number of broiler hen and layer hen between 2008 and 2009.

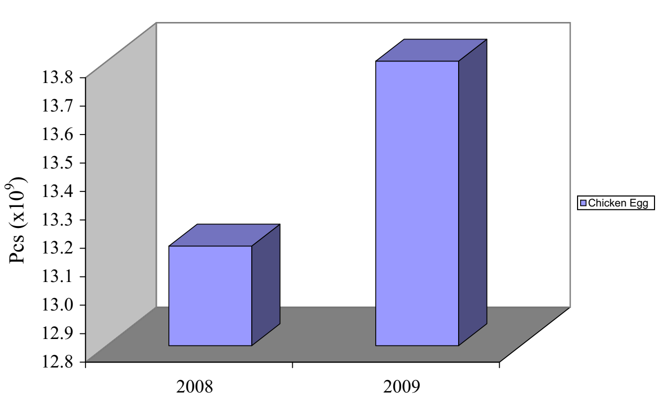

Fig. 8. Number of chicken eggs between 2008 and 2009.

2. Renewable energy use in agriculture

Although agricultural production rate has been decreased economically, in terms of supplying food for Turkish people, exportation, and industry sector, agriculture is still keeping its importance. Although the agricultural activities are so important, current energy sources are originating from fossils. So, these fossil sources cause environmental pollution and harm the fields used for agricultural activities.

Coal is the major fuel source for Turkey. Domestically produced coal accounted for about 24% of the country's total energy consumption, used primarily for power generation, steel manufacturing and cement production [6]. Also, there are natural gas and fuel oil that are acquired from neighboring countries. In contrast with these sources, Turkey has wide range of renewable energy resources, such as solar energy, biomass energy, wind

Table 1a
Renewables and wastes in Turkey.

	Municipal waste* (GWh)	Industrial waste (GWh)	Primary solid biomass (GWh)	Biogas (GWh)	Liquid biofuels (GWh)	Geothermal (GWh)	Solar thermal (GWh)	Hydro (GWh)	Solar PV (GWh)	Tide, wave, ocean (GWh)	Wind (GWh)
(a)											
Gross elec. generation	0	77	24	118	0	162	0	33,270	0	0	847

	Municipal waste* (TJ)	Industrial waste (TJ)	Primary solid biomass** (TJ)	Biogas (TJ)	Liquid biofuels (1000 tones)	Geothermal (TJ)	Solar thermal (TJ)
(b)							
Production	0	924	199,518	1091	20	48,178	17,584
Transformation	0	924	411	1091	0	5849	0
Electricity plants	0	924	151	1091	0	5849	0
Final consumption	0	0	199,107	0	20	42,329	17,584
Industry	0	0	0	0	0	0	5275
Transport	0	0	0	0	20	0	0
Residential	0	0	199,107	0	0	42,329	12,309

energy, geothermal energy and hydropower. Usage of these energy resources for agricultural activities can afford lots of advantages to the farmers in economical, social and environmental conditions, and this situation is called "sustainable development" which is important for a country.

2.1. Solar energy in agriculture

"Solar energy" applications in agriculture, as one of the renewable energies, are firstly greenhouse heating and cooling, then lighting, product drying, solarization and farm field irrigation. Turkey has an advantage about duration of sunshine; it is mostly sunny. Figs. 9 and 10 show radiation values and duration of sunshine [7].

2.1.1. Greenhouse heating/cooling by solar energy

Greenhouses are the one of the best areas to have great success by using renewable energies. Using renewable energies can supply increasing product quality, decreasing production costs and energy savings. Cooling and heating systems in greenhouses can be active or passive systems.

Active heating systems, by using solar energy, have heat gathering and storage units apart from greenhouses' parts. Thus heat energy is obtained both from solar radiation on greenhouse blanket and active heating system's heat gathering units. Energy is stored in suitable units and these units help to heat greenhouses.

Passive heating systems' heat gathering units are mostly placed inside greenhouses. Besides this, greenhouses are planned and built to have high yield of energy savings, so greenhouses can act as heat gathering units by their own. To apply this condition, greenhouses build throughout east-west directions. Inside greenhouse, obtained heat from solar radiation is stored in a heat storage material by using a fluid and is used when needed. Furthermore, heat drapes, mulches and water mattresses can be used for heat savings [8]. Both in active and passive systems it is preferred to verify the best environmental conditions for the plants growing in greenhouses (stable temperature, suitable moisture and homogenized condition in all over the greenhouse).

Obtained heat energy from sun can be transferred to another material by storing or storage by phases changing [9]. Heating or cooling systems cannot be used only on sunny days. Heating can also be carried out on cloudy days or nights by using energy storage units. So, in unsuitable air conditions, greenhouses keep warm and plants can grow up with high yield with the exception of bad conditions.

In the last few years, to heat greenhouses by solar energy, water mattresses are chosen and they are also cheaper when compared to other methods. For this purpose, called PE, 25–35 cm diameter pillows shaped like pipes are being used. They are placed throughout greenhouse between plant lines and full of water. Mattresses act like solar collectors and spread the heat during all night through the greenhouse. This can change the temperature of the medium of the greenhouse to about 2–4 °C. With these mattresses, heat drapes can be used to increase the temperature difference of up to 4–7 °C [10,11].

Cooling systems are almost same with heating systems. The differences between these two systems are heat pumps and style of absorption of heat. Parabolic solar collectors, condensed combi boiler and heat pump are included in these systems. These systems started to be more common to use in greenhouses because their cooling power (5–35 kW) has low emissions.

With some systems, it is possible to warm up or cool down a greenhouse. By using parabolic groove collector, temperature can be raised up to 180–200 °C and in this warmth water turns into

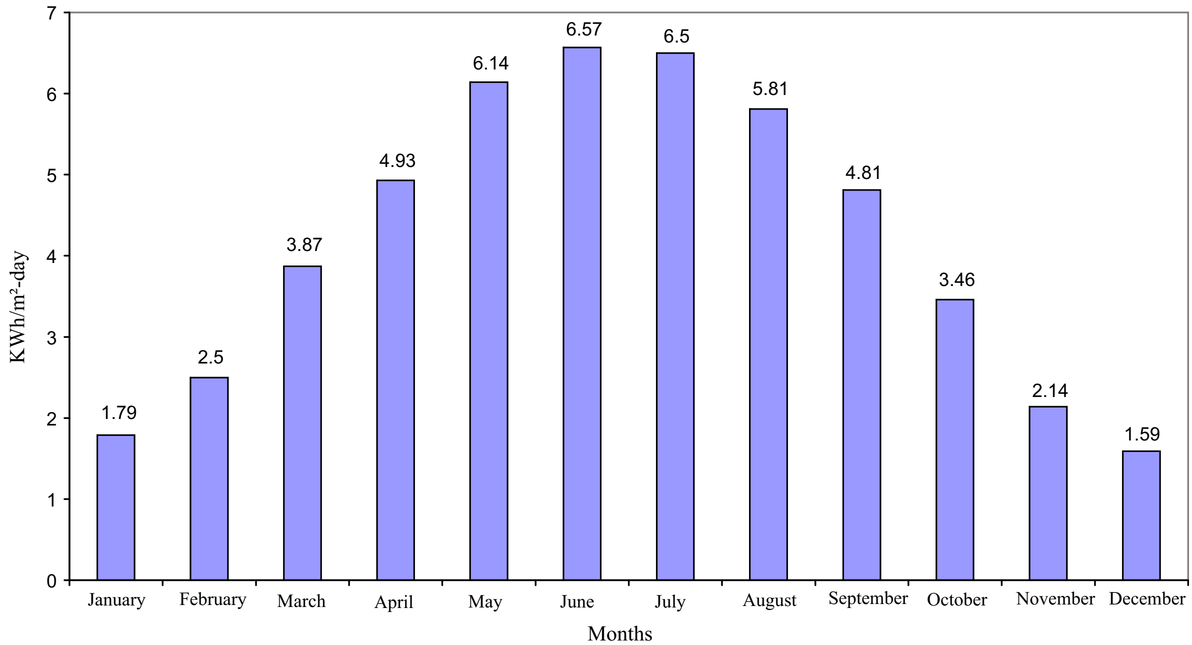

Fig. 9. Turkey's global radiation values [7].

vapor to be used both in direct heating systems and absorption controlled cooling systems [12].

2.1.2. Food drying by solar energy

Food drying is the most common method that has been used since hundreds of years. Food's water activity is reduced by keeping them under sun and making them dried. But this method is not safe for food hygiene and quality. Food, kept outside to be dried, is defenseless against contaminations from air conditions, pollution and microorganisms. It also causes the change in food's quality. Food drying systems by solar energy can remove these disadvantages and it is useful also for sunless states and in daytime. Proposal drying temperetures for some products are given in Table 3 and Turkey's drying food amounts in a year are given in Table 4.

There are three different application methods of drying systems with solar energy; these are convection, radiation and conduction. In convection systems, a gas is needed to supply heat for water conversion to vapor. This gas is usually ensured from air. Hot air passes through inside, above and among the material that is needs to be dried. Process of conduction drying system works due to transportation of heat with in a contact area. In this way, the material,

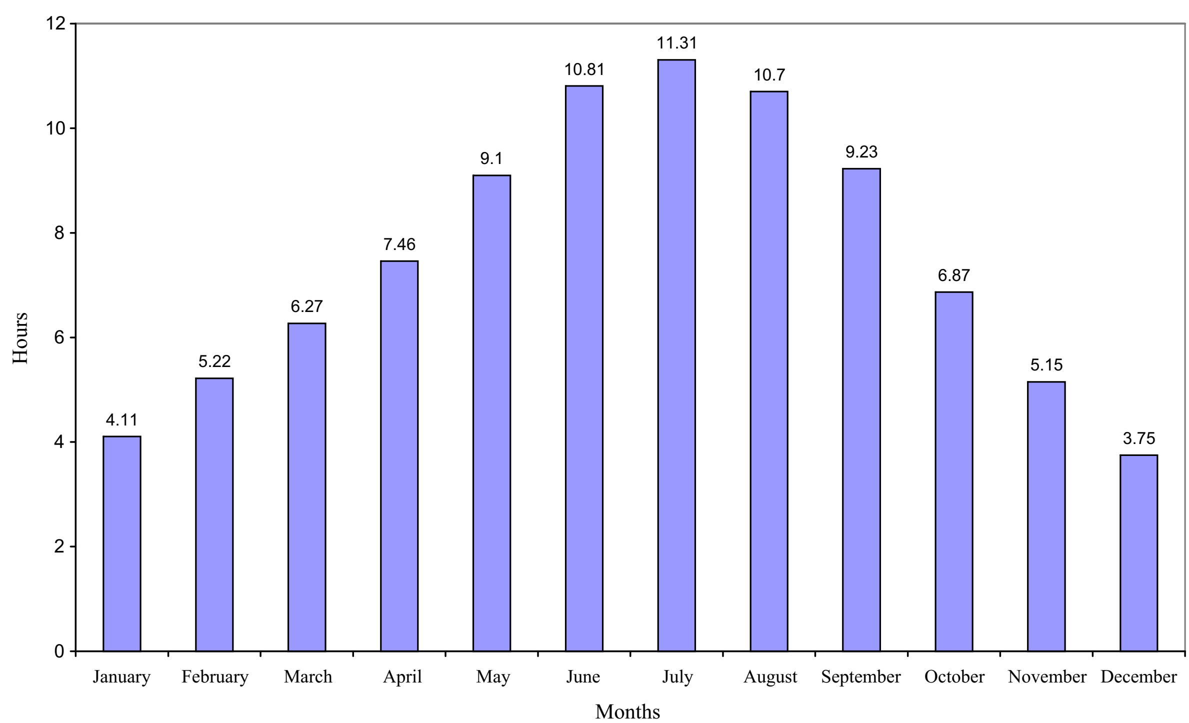

Fig. 10. Duration of sunshine [7].

Table 2
Renewable energy potential of Turkey [5].

Classification of renewable energy	Usage kind of energy	Natural potential	Technical potential	Economical potential
Solar energy	Electrical energy (billion kWh)	977,000	6105	305
	Heat (Mtoe)	80,000	500	25
Hydraulic energy	Electrical energy (billion kWh)	430	215	124.5
Wind energy				
Direct terrestrial	Electrical energy (billion kWh)	400	110	50
Direct maritime	Electrical energy (billion kWh)	–	180	–
Sea wave energy	Electrical energy (billion kWh)	150	18	–
Geothermal energy	Electrical energy (billion kWh)	–	–	1.4
	Heat energy (Mtoe)	31,500	7500	2843
Biomass energy	Fuel (classic) (Mtoe)	30	10	7
	Fuel (modern) (Mtoe)	90	40	25

Fig. 11. Food drying system by solar energy in Gaziemir/İZMİR.

Table 3
Products and proposal drying temperatures.

Product	Temperature (°C)	Product	Temperature (°C)
Apple	74	Apricot	71
Cabbage	63	Carrot	79
Fig	71	Sour Cherry	71–77
Grape	71	Onion	88
Peach	66	Pear	63
Potato	66	Plum	74–77
Banana	70	Garlic	55
Medical plants	35–50	Pepper	55
Chili pepper	35–40	Coconut	35–40
Bean	75		

Table 4
Drying food amounts in a year in Turkey (ton).

Product	Amounts (tones)
Tomato	16,873
Eggplant	91
Sweet-corn	7
Agaricus fungus	34
Carrot	0.1
Leek	89
Spinach	0.1
Onion	21
Gourd	105
Other vegetables and mixed vegetables	277
Cauliflower	11
Bamia	9
Garlic	7

which needs to be dried, gets the heat from hot area both of the situation that stay stabilized or keep moving. Drying system with radiation does not need any heat transportation material; it just needs radiation sources such as microwave, dielectric, and infrared beams. In Fig. 11, the food drying system by solar energy in Izmir is seen. The area covered with green blanket is solar collector's area and it is covered because of sun beams' directions [13].

In summer time, beams come straight right, so there is also overheat and this blanket's function is to prevent the collectors.

In this drying system, 3 tones of grapes can be dried and their qualities and microbiological criterions match with the all the food standards.

There are a few disadvantages of this system. Drying procedure is slow and it is dependent on insolation time. At the same time, it performs a homogenized drying, purifies, and prevents environmental conditions (such as microorganisms, dusts, etc.) and keeps foods secure. This drying system's total cost (collectors, engine, shelves, fence, etc.) is 6000 TL. It can look like expensive but every single year, lots of foods are buried because of wrong drying styles. These burying foods' costs are more than this system's. According to TUBITAK's (The Scientific & Technological Research Council of Turkey) research, 40% of foods are thrown because of wrong drying. This mean that just for one year, the loss is 10,000,000 $ per food [14].

For Turkey's total exportation, dried foods have a serious place. It can be clearly seen that dried food income for Turkey below. Tables 5 and 6 show the amounts of dried fruit and its goods, vegetables, legumes, hazelnuts, etc. percentage of exportation in Turkey.

Table 5
Amounts and percentage of dried foods in Turkey's exportation ratio [15].

Sectors	March		
	2010 (thousand $)	2011 (thousand $)	Percent
Dried fruit and goods	85,122	112,729	1
Agricultural sector	1,228,086	1,484,457	12.7
Industrial sector	8,075,113	9,956,026	84.9
Mining	242,148	282,182	2.4
Turkey's total exportation	9,545,347	11,722,665	100

Relevant to drying, some Turkish universities have designed different types of drying systems and had different applications. In Ege University Solar Energy Institute, perpendicular axis following sun cabinet typed drying system has been designed in 1991 [16] and, in 2000, a doctorate thesis called "solar drier powered by photovoltaic system with special application to tomatoes drying" had been carried out, and successful results had been obtained [17]. Also, in a study in Gazi University Mechanical Engineering department, heating the air current between perpendicular-occasioned two transparent panels with solar energy and using it in drying systems are researched (1997) [18]. In a solar drying oven study performed in Ege University Solar Energy Institute, aluminum string was placed into flow canal and used as an absorption surface. It is aspired to enlarge the heat transfer surface by painting the aluminum string in black (1988) [19]. In Karadeniz Technical University department of Engine Engineering, heat pump system, including solar collectors and energy storage, is set up to make dry and climate for Black Sea Area (1990) [20]. In Gazi University Technical Education Faculty, drying oven is designed and it includes solar energy condensation (1988) [21].

2.1.3. Solarization

Soil solarization, a non-chemical technique, will control many soil-borne pathogens and pests. This simple technique captures radiant heat energy from the sun, thereby causing physical, chemical and biological changes in the soil. Transparent polyethylene plastic placed on moist soil during the hot summer months increases soil temperatures to levels lethal to many soil-borne plant pathogens, weed seeds and seedlings (including parasitic seed plants), nematodes and some soil residing mites. Soil solarization also improves plant nutrition by increasing the availability of nitrogen and other essential nutrients.

Till year 2005, methyl bromide was used to kill pathogens and undesirable plants. But it has been forbidden because of its harm to ozone layer since 2005 in developed countries and also it will be not allowed to use after year 2015 in developing countries. In Turkey, it has been banned since 2008. About this decision, delegates, from 160 different countries, signed a protocol named "Protocol of Montreal". In year 2003, Institute of West Mediterranean Agricultural Research coordinated a project with KORGEM (Republic of Turkey, Ministry of Agriculture and Rural Affairs, General Directorate of Protection and Control Vision) named "Phase out of MeBr for soil fumigation in protected horticulture and cut flower production in Turkey". This project is being carried out in Adana, Antalya, Aydın, Isparta, İzmir, Mersin and Muğla cities in Turkey [22].

Solarization is less expensive than the other methods for soil reform, is simple and free from danger. It can also increase the amounts of some inorganic substances. Consequently, solarization is chosen more than the other methods [23].

Although most mesophilic organisms in soil have thermal damage thresholds beginning around 39–40 °C, some thermophilic and thermotolerant organisms can survive temperatures achieved in most types of solarization treatment [24]. Firstly, solarization is dependent on high levels of solar energy, as influenced by both climate and weather. Cloud cover, cool air temperatures, and precipitation events during the treatment period will reduce solarization efficiency [25]. Solarization is commercially practiced mainly in areas with Mediterranean, desert, and tropical climates which are characterized by high summer air temperatures. In order to maximize solar heating of soil, transparent plastic film is most commonly used for solarization. Transparent film allows passage of solar energy into the soil, where it is converted into longer wavelength infrared energy. This long wave energy is trapped beneath the film, creating a "greenhouse effect". Opaque black plastic, on the other hand, does not permit passage of most solar radiation. Rather, it acts as a "black body" which absorbs incoming solar energy. A small portion of the energy is conducted into soil, but most of the solar energy is lost by reradiating into the atmosphere. Nevertheless, solarization with black or other colors of plastic mulch is sometimes practiced under special conditions [26].

Apart from solar irradiation intensity, air temperature and plastic film color, other factors play roles in determining the extent of soil heating via solarization. These include soil moisture and humidity at the soil/tarp interface, properties of the plastic, soil properties, color and tilth, and wind conditions. The procedure of covering very moist soil with plastic film to produce micro-aerobic or anaerobic soil conditions, but without lethal solar heating, by itself, can produce varying degrees of soil disinfestations [27].

In Turkey, solarization is being used in 45,000 ha covered area. Most common application areas are the Mediterranean Sea shores and the Aegean area. It is being used to produce the vegetables in Antalya-Kumluca; strawberries, pepper and eggplant in East Mediterranean; strawberries in Aydın and now started to being used in Tokat in greenhouses.

In some cities (İzmir, Muğla and Antalya) in Turkey, greenhouse production is still continuous in summer time. Because of this situation, solarization cannot be applied to these areas during all July and August [28]. Still, some research centers, universities and institutes are studying on solarization to make it better for all conditions. One such institute is Ege University Solar Energy Institute, in which effects of different types of plastic materials in soil solarization named topic has been researched and practically tested (1998) [29].

2.1.4. Agricultural irrigation with solar energy

Agricultural irrigation is mostly carried out with using power of electricity, diesel fuel or petroleum to operate water pump in

Table 6
Turkey's total exportation values based on all sectors [15].

Sectors	2009–2010 (thousand $)	2010–2011 (Until 31st March) (thousand $)	Percent
Cereals, Legumes, Oily Seeds ve Goods	3,729,009	4,329,972	29.1
Wood Goods and Forest Products	2,627,264	3,044,697	20.5
Fresh Fruit and Vegetables	2,013,079	2,333,040	15.7
Hazelnuts and Goods	1,280,632	1,630,576	11.0
Dried Fruit and Goods	1,109,029	1,311,593	8.8
Ship and Yacht	1,669,750	1,201,839	8.1
Aquaculture and Animal Products	850,536	1,028,273	6.9
Total	13,279,299	14,879,991	100

Turkey. Solely, these systems have some disadvantages; it is expensive, the need for maintenance per day and they are only setting up in areas where it is easy to reach, and not with huge water sources.

As an alternative, there are solar energy supplied water pump systems that depend on solar energy and can be used wherever it is needed. They are durable, no fuel and maintenance are needed day to day. Although, initial set-up costs are higher than the others, their feasibilities are better. These systems are attended to energy needed and demands due to air conditions caused by drought and high temperature during the summer. Solar panel number can vary depending on land scale and irrigation needed. Electricity gained from panels is being used for water pumps to irrigate. According to farm scale, there are different types of irrigation and the electric power gained in this manner is used for production. Minimum irrigation necessity (0.3 l/day-plant root irrigation: 616 Wp) and maximum irrigation necessity (1000–10,000 l/day) conditions can be fixed and systems can be designed for the situations.

One of the most promising applications of PV solar power, especially in countries, which have very high levels of solar radiation, is for pumping the water needed to irrigate certain crops. For the connection between the irrigation system and PV solar-powered pumping equipment to be energetically and economically efficient, the following points have to be taken into account: (i) efficient use must be made of the water resource, i.e., only the amount of water needed for the crop should be raised. This amount should, in turn, take into account the soil's rainwater retention capacity during the wet season; (ii) this amount of water should be raised to the minimum height above ground level needed to stabilize the pressure at the irrigation heads; and (iii) the most efficient irrigation system for that particular crop should be adopted [30].

Considering the possibilities for maintaining water tables through appropriate management at relatively shallow levels and in view of the narrowing limits in conventional power supply in India, solar power offers an effective alternative for drawing irrigation water from shallow wells and from surface water in rivers, canals or tanks. Moreover, the suitability of solar power for lifting water to irrigate plants is undeniable because of the complementarily between solar radiation and the water requirements of plants. The more intensively the sun, is shining, the greater is the power to supply irrigation water, while on the other hand on rainy days, irrigation is neither possible nor needed. Electrical power supply, on the other hand, has maximum shortage when demand for irrigation is at a maximum.

The mechanical conversion of solar energy is possible either via photovoltaic generation of electricity or via the thermodynamic process of producing steam to generate kinetic energy directly. An ex-ante comparison of the estimated costs of water supply by Diesel powered engines vs. photovoltaic vs. solar-thermal power sources has shown that a solar thermal system is likely to offer considerable advantages in costs of manufacturing and operation over the alternatives [31].

There are applications about irrigation by solar energy in Turkey. One of those is drilling water from ground by using only energy gained from solar panels by UCTEA Agricultural Engineers Association Konya Branch Office [32]. Drip irrigation systems are advised to make it more economic.

In Ataturk Orman Ciftligi/Ankara (Ataturk Forest Farm), 616 Wp powered irrigation system has been set up and by a diver pump in 7 m, 11,000 m^3 water has been pumped to the farms [33].

In General Directorate of Electrical Power Resources Survey and Development Administration's Renewable Energy Park, 756 Wp powered water pump system is being used for irrigation, and also in Adana-Ceyhan, 300 decare land is being deliquescing by using solar energy [34].

2.2. Biomass energy in agriculture

The main indigenous energy resources of Turkey are lignite, hydro and biomass. Electricity is mainly produced by thermal power plants, consuming coal, lignite, natural gas, fuel oil and geothermal energy and hydro power plants in Turkey [35].

Bioenergy represents about two-thirds of renewable energy production in Turkey. Various agricultural residues available in Turkey, such as grain dust, wheat straw and hazelnut shells are the main sources of biomass energy. The total forest potential of Turkey is around 935 million m^3, with an annual growth of about 28 million m^3 [36].

Biomass energy goes into division as classic and modern. As modern biomass energy technologies, energy forestry and energy crops production can be counted [37].

In terms of energy forestry in Turkey, as economically valuable, fast growing trees such as aspen poplar, quaking aspen, brazilwood, calabrian pine, oak, ash tree, pinus pinea, black pine and cypreas can be counted. It is important that to plant not only the trees which want more irrigation, such as poplar, willow, but also should plant trees which can grow up in more drought fields. 15% of the suitable fields for energy forestry are recovered and remaining fields (85%) are still waiting to be utilized [37].

To apply modern biomass energy technology, energy crops production, planning of energy and planning of agrarian production have to be considered together. Theoretically gross potential of biomass energy is calculated about 135–150 Mtoe/year, and also, after losses are deducted, it is assumed that net value will be 90 Mtoe/year. However, all production fields cannot use only biomass energy materials during a year. It is just 40 Mtoe/year according to highest efficiency on production of biomass energy crops, energy forestry, etc. [37].

As modern biofuels, bioethanol, biogas, biodiesel, gases obtained from gasification, products of pyrolyses, biomethanol, biohydrogen, etc. can be counted. All this kind of biomass energy can be used for agricultural activities. But also, they firstly have to grow up. So, using biomass energy in agriculture and biomass resources production are related with each other.

2.2.1. Bioethanol

Bioethanol is produced from different carbohydrates sources, such as including sugar, starch and lignocellulosic materials. These agricultural products are also important as food and animal feed. So, it is more advisable that to use of their residues and wastes to product bioethanol.

As a sample, suitable field for sugar beet growth, which is important for bioethanol production, is about 4.5 million decare equal to 2–2.5 million tones of bioethanol [38]. This ethanol can be used with or/and instead of fuel oil. Legally, adding 5% of bioethanol can be accepted, but 2% is only allowed to use bioethanol without private consumption tax. Without any modification, 10% of bioethanol can be used in engines of automobiles, public service vehicles and tractors. The primary raw materials for bioethanol production in Turkey are:

- Sugar beet and residues
- Potato
- Molasses
- Wheat straw
- Corn and corncobs
- Lignocellulosic biomaterials [39].

For Turkey, the best feasible raw materials are sugar beet, corn, potato, cossette and other cellulosic raw materials. Some of the bioethanol raw materials potential of bioethanol production is shown in Table 7 [40].

Table 7
Bioethanol raw materials and production potentials.

Raw Materials	Bioethanol production potential (l/ton)
Sugar cane	70
Sugar beet	110
Sweet potato	125
Potato	110
Cassava	180
Corn	360
Rice	430
Barley	250
Wheat	340
Cossette and other cellulosic biomaterials	280

Table 8
Ethanol factories in Turkey and production potentials [42–45].

Factory	Ethanol production potential (m^3/year)
Eskişehir alcohol fac.	21,000
Turhal alcohol fac.	14,000
Malatya alcohol fac.	12,500
Erzurum alcohol fac.	12,500
Çumra Şeker – alcohol fac.	84,000
Tarkim	40,000
Tezkim	26,000

As it has been written above, bioethanol can be used in engines as fuel oil or instead of it. For agricultural activities, using bioethanol in tractors with fuel oil or just itself can decrease the costs of gasoline and also help to prevent air pollution. Bioethanol can be used in generators as energy source, so it can generate electricity for lighting barns, coops, garden and house. But, production process of bioethanol has been in jeopardy because of the microorganisms and their sterilization need. If there is any complication in the reactor, whole process, energy and time would be lost. That is why it is hard to product bioethanol in farm-scale reactors.

Turkey's fields are eligible for agricultural activities and biomass resources can be grown. As late as this, it is hard to use these raw materials to product bioethanol because of the legal impossibilities and increases of the raw materials' food product importance. All these conditions cause increasing of the price of bioethanol production in Turkey.

In a complete cycle, 10% bioethanol is used instead of 100% fuel oil; if ethanol has been produced from cereals, gas emission decreases about 3–4% and if ethanol has been produced from cellulosic biomaterials, decrease ratio is about 6–8%. If 85% bioethanol is used instead of 100% fuel oil, net emission values can be decreased to 75% [41]. At present, only in Çumra Şeker, which belongs to Konya Şeker Manufacturer, bioethanol production continues. Also, there are seven factories that could product bioethanol. But because of the reasons indicated above (legally issues and biomaterials production problems) those factories cannot produce and have left production hanging [42].

Petrol Ofisi (PO) is the only fuel oil company that uses the bioethanol in Turkey. Although, the legal rate is 5%, PO uses the rate just 2% because of the private consumption tax [43].

According to information from PO, sale of unleaded fuel (95 octanes) is approximately 600,000 m^3/year and this entire amount is biofuel. In existing circumstances, ethanol needed is approximately 62,000 m^3/year. The production of ethanol for this amount is:

- 64,500 tones wheat,
- 72,500 tones corn or,
- 210,000 tones sugar beet should be used.

With a regulation about using mixture of ethanol and fuel oil in the private consumption tax, the needed ethanol amount would be 157,000 m^3/year. [44].

The potential ethanol production amounts by the factories are shown in Table 8.

2.2.2. Biodiesel

Biodiesel is another bioenergy kind gained from oleaginous seeds such as canola, safflower and sunflower. Also, used frying oil, fish oil can be chosen. Biodiesel can be used in pure form (B100) or may be blended with petroleum diesel at any concentration in most injection pump diesel engines. Blends of biodiesel and conventional hydrocarbon-based diesel are products most commonly distributed for use in the retail diesel fuel marketplace. Much of the world uses a system known as the "B" factor to state the amount of biodiesel in any fuel mix:

- 100% biodiesel is referred to as **B100**, while
- 20% biodiesel is labeled **B20**;
- 5% biodiesel is labeled **B5**;
- 2% biodiesel is labeled **B2** [46].

In Turkey, by 2006, amount of rapes planting is 54,000 decare (0.8%) in 6.6 million decare oily seed planting and 12,600 tones (0.45%) in 2.8 million tones oily seed production [47].

Biodiesels are characterized by their viscosity, density, cetane number, cloud and pour points, distillation range, flash point, ash content, sulfur content, carbon residue, acid value, copper corrosion and higher heating value (HHV). These parameters are all specified through the biodiesel standard, ASTM D 6751. This standard identifies the parameters that the pure biodiesel (B100) must meet before being used as a pure fuel or being blended with petroleum-based diesel fuel [48].

The biggest advantage of using biodiesel is environmentally friendly that it has over gasoline and petroleum diesel, its portability, ready availability, renewability, higher combustion efficiency, lower sulfur and aromatic content [49], higher cetane number, and higher biodegradability [50]. Also, using biodiesel benefits as economically because of potential amounts and it can reduce import of fuel oil amounts from abroad.

Turkey has been producing just 15% of its total petroleum consumption; the rest is imported from outside the country. Moreover, having been widely used in both road and sea transportation, and for industrial purposes, diesel has the largest share of 34% in the petroleum consumption of the country. Therefore, biodiesel as one of the renewable resources can be an alternative for diesel consumption in this country. Since the awareness of environmental issues in recent years is likely to increase the demand for biofuels throughout the world, biodiesel can be considered to be one of the important alternative renewable energy sources for an oil-dependent country. Moreover, biodiesel production surely brings some economic gains such as rural development and reduced greenhouse gas emissions compared to other standard petroleum products. However, there are other problems that result from the expansion of the agricultural frontier, such as deforestation, monocropping, water pollution and food security, etc. These issues should also be taken into consideration before implementing a roadmap for increasing the future potential for renewable energy, a major part of which includes biodiesel in Turkey [51].

2.2.3. Biogas

Biogas, which is obtained from organic materials after anaerobic fermentation, is flammable and similar with natural gas. This gas contains 40–70% methane, 60–30% carbon dioxide and other gases (hydrogen sulfide, hydrogen, nitrogen, carbon monoxide). It can be used where natural gas and/or LPG is used.

Biogas can be produced by agricultural materials, such as animal wastes (cattle, chicken, pig, sheep, etc. manures), industrial wastes (slaughter house wastes, blood, fish wastes, etc.), plantal wastes and residues (corn and corncob, wheat straw, grass, clover, leaves, etc.) and domestic wastes [52].

Biogas is just a biofuel but its importance is to control and collect organic waste materials and at the same time producing fertilizer and water for use in agricultural irrigation. Unlike other forms of renewable energy, biogas neither has any geographical limitations and required technology for producing energy nor is it complex or monopolistic [53].

As known, there is a rich list of organic wastes that can be used for biogas production. So, in rural areas and for agricultural activities, biogas and biogas raw materials are intimate. Agriculture residues and wastes, and animal wastes are mostly used in biogas systems. It is an anaerobic fermentation process and in mesophilic conditions (depends on waste qualification) it takes 12–45 days. The biogas can be used with small modifications in combi, oven, oil lamp, automobiles and all internal combustion engines. This bioenergy can be converted to thermal energy, warm water to heat houses, barns, etc. and electricity by using co-generation unit. Also, there is a by-product, called organic fertilizer after biogas production. Feed materials after biogas process convert into fertilizer. This can be used for agricultural activities, energy crops production, forestry and other crops production, which are important as a food for human nutrition and as raw material for bioenergy production.

Organic fertilizer is better than other common fertilizers. Its C/N rate (carbon/nitrogen rate) is better for plants growing; pathogen microorganisms are removed by fermentation, and it prevents fly-blowing by deodorizing. Organic fertilizer raises the yield of crops production up. So, farmers can harvest more and healthier vegetables, fruits and cereals.

It is estimated that the total biomass energy potential is approximately 16–32 Mtoe and animal wastes are 2.3 Mtoe. Especially in rural areas, using biogas is really economic by using it to cook and heat. Biogas production amounts only from animal wastes is estimated about 2.2–3.9 billion m^3 [52].

Biogas production and systems is being kept to study and research by numerous universities, institutes, research centers, state institutions and organizations in Turkey. The common aim of these researches is to make biogas systems and its usage more widespread. Ege University Solar Energy Institute (EU-SEI) Energy Technology division, Biomass Energy Technologies Research Group has been working on biogas production, systems and to make it widely used since 2000, and also has two important biogas projects. One of these projects is supported financially by Turkish Republic Prime Ministry State Planning Organization (SPO) and the project's name is "Development and Widespread of Biogas System for Rural Area". This one is for rural areas and to help their development by using biogas systems. With this project, farmers can generate their own energy by using animal manure and their own agricultural residues, plants and crops. Also, the organic fertilizer is such a gift for them because of its qualification for agricultural activities. In addition to this, master, doctorate degree thesis and scientific research studies about biogas production, systems, utilization, and benefits are still continuing in EU-SEI. These are automation of a prototype biogas reactor, about monitoring and controlling all parameters in whole biogas production process [54], investigation of co-fermentation by using different kinds of agricultural wastes in biogas production [55], exergy analysis of biogas production processes [56], and design, manufacture, trial run and investigation of parameters impacting its performance of biogas systems for rural use [57] can be counted as some of the research topics about biogas. EU-SEI's other ongoing project is carried out in collaboration of Kocaeli Metropolitan Municipality, TUBİTAK-MAM (The Scientific & Technological Research Council of Turkey, Marmara Research Center), Akdeniz University, Kocaeli University and Süleyman Demirel University. The project name is "The Production of Biogas from Agricultural and Animal Wastes and Utilization of Obtained Gases in Integrated Energy Conversion Technologies" and supported financially by TÜBİTAK. This project's aim is to build up a central biogas system and to deliver the energy. Apart from these, there are a few application areas about biogas production systems in Turkey:

- TÜBİTAK (The Scientific & Technological Research Council of Turkey) has a biogas project in Kayseri. There are mostly cattle, sheep, goat and chicken stock raising and their manures are used to produce biogas [58].
- By the Enertek Energy Production Inc., a biogas system (installed power is 4.25 MW and energy production is 34 GWh) has been built in sanitary landfill in Çiğli/İzmir [59].
- By the Fortuna Energy Investment Ind. Trade. Co. Ltd., in Germencik/Aydın, a biogas system, installed power is 1063 MW and energy production is 8 GWh, has been built. In this system, corn silage and cattle manure are used [60].
- By the Enertek Energy Production Inc., a biogas system (installed power is 3.88 MW and energy production is 29.5 GWh) has been built in wastewater treatment facility with mud in Çiğli/İzmir [61].
- By Ranteko, in Çiçekdağ/Kırşehir, 250 kW capacity biogas system has been built. In this system cattle manure is used [62].
- Depending on the protocol between Ege University Solar Energy Institute Biomass Energy Technologies Research Group and ÖR-KOOP (Nazilli and Neighborhood Agricultural Development Cooperative), a biogas system has been built in 15/04/2007 in Ülkü Farm, Aydın-Kuyucak-Pamukören. Reactor capacity of this system is 60 m^3, and gas storage tank capacity is 50 m^3, so, biogas production is 60 m^3 per a day [52].

2.3. Geothermal energy in agriculture

Turkey is located on the Mediterranean sector of Alpine-Himalayan Tectonic Belt. At the same time, this young belt is a significant geothermal belt. Geothermal fields are caused from the Graben systems of Western Anatolia, widespread volcanism and tectonics of Central, the Eastern Anatolia, and right lateral and strike slip North Anatolian Fault zone [63].

Turkey has important potential for geothermal energy production, possessing one-eighth of the world's total geothermal potential. Much of this potential is not suitable for electricity production but still useful for direct heating applications [64]. Total geothermal potential of Turkey, around 94% is appropriate for thermal use (temperature less than 150 °C) and the remainder for electricity production (temperature more than 150 °C). The geothermal electricity generation capacity potential of Turkey is estimated at 2000 MW (16 TWh/year) and a generation capacity of 550 MW that utilizes geothermal sources is expected by the year 2013. The main utilization of geothermal energy in Turkey is generally in domestic heating, greenhouses, spas and thermal resorts. The overall geothermal heat generation potential of Turkey is about 31,500 MW, using part is about 4000 MW and electricity generation is 93 MW. [65].

Agriculture and the food processing industry are promising fields for the practical use of geothermal energy, since there are many technologies which need more or less concentrated heat energy sources. However, depending on the characteristics of the food technology, use of geothermal energy varies greatly, too [66]. Table 9 shows temperature rates of process heat demands of selected agro-industrial technologies [67].

Mineral Research & Exploration General Directorate (MTA) has found 173 geothermal fields since 1962. In 2005, 21 geothermal

Table 9
Process heat temperatures required by different agro-industrial processes.

Technologies	Temperature (°C)
Drying of cereals	40–80
Drying of green crops	80–135
Greenhouse heating	60–130
Soil heating	20–35
Animal house heating	25–60
Milking parlors	40–95
Warm water irrigation	20–35
Aquaculture	15–35
Mushroom growing	20–50
Food preservation	90–150
Milk processing	70–120
Meat processing	40–85

well had been drilled and 184.5 MW energy potential had been revealed, and totally 11,179 m deep drilling had been carried out [68].

Table 10 shows the existing geothermal fields and their temperature ranges.

2.3.1. Use of geothermal energy to heat the soil in open fields

This kind of heating is mostly used to make more economically for production in early spring and late autumn. The important parameters are heating pipes' depth and interim, pipe material, soil temperature and effects of soil temperature on plant growing [69].

2.3.2. Use of geothermal energy in barns

Geothermal energy can be used to adjust suitable conditions in barns. As a sample, if 50 °C geothermal water is being used in a farm, facility's caloric power is 372 kW. Geothermal water can be pumped without ventilation from tank, and 25 °C water intermingles with water in the system and is gathered in tank [70].

2.3.3. Use of geothermal energy to dry agricultural products

Drying of fruits, vegetables, cereals and other agricultural crops need most energy-related agriculture energy consumption. Geothermal energy can take place instead of classical methods because of its specificity to control drying temperature. It is important that the temperature rank of geothermal water and needed temperature to dry crops [71].

2.3.4. Use of geothermal energy in aquaculture

Aquaculture is one of the directly used geothermal energy. Application temperature in aquaculture changes by depending on fish type; however, geothermal resources can be used for aquacultural activities in the temperature ranges between 21 °C and 27 °C. This temperature rank allows breeding different kinds of fishes. Geothermal energy's heat is more important than geothermal fluid. For shrimp and catfish the suitable temperature is 30 °C, for trout and salmon, it is up to 15 °C. These temperature ranges can easily be regulated by using geothermal energy [72].

Table 10
Geothermal fields and temperatures [69].

Field	Temperature (°C)
Denizli-Kızıldere	200–242
Aydın-Germencik	200–232
Manisa-Alaşehir-Kavaklıdere	213
Manisa-Salihli-Göbekli	182
Çanakkale-Tuzla	174
Aydın-Salavatlı	171
Kütahya-Simav	162
İzmir-Seferihisar	153
Manisa-Salihli-Caferbey	150
Aydın-Sultanhisar	145
Aydın-Yılmazköy	142
İzmir-Balçova	136
İzmir-Dikili	130

Table 11
Districts that use geothermal energy for heating greenhouses, capacities and areas.

Location	Capacity (MWt)	Area (ha)
Dikili-İzmir	77.8	4.59
Salihli-Manisa	14.3	2.50
Turgulu-Manisa	15.4	1.10
Balçova-İzmir	10.5	1.00
Kızıldere-Denizli	18.8	1.58
Gümüşköy-Aydın	2.5	0.50
Diyadin-Ağrı	3.1	0.024
Karacaali-Urfa	10.0	0.6
Sındırgı-Balıkesir	3.0	0.2
Simav-Kütahya	10.0	1.0
Total	165.4	13.9

2.3.5. Use of geothermal energy in soil improvement

Soil improvement is needed to prevent undesired and harmful plants in crops production. Also, the carried water with irrigation, contents salt and by the time, water vapors, but salt accumulates into soil. This kind of soil is not suitable for agriculture. So, it needs improvement. With geothermal energy, it is possible to form the soil back again [73].

2.3.6. Use of geothermal energy in greenhouse

The essential task of each greenhouse construction is to enable the creation and maintenance of optimal conditions for protected plant cultivation, independently or of controlled dependence on the outside to eliminate conditions. The main phenomena involved are the plant photosynthesis and respiration [74]. It is very important to determine the flow rate needed for irrigation in oases during the heating period in order to calculate the appropriate area of the greenhouse project and to avoid water disequilibrium between heating and irrigation purposes [75].

By using geothermal energy, the temperatures between 20 °C and 60 °C can be reached in greenhouse heating processes [69].

Heating of greenhouses using geothermal fluids has become very popular in Turkey in recent years. Table 11 shows the major greenhouse heating areas and the estimated thermal power being provided; most of these greenhouses are in Western Anatolia. The one in operation cover more than 13 ha and it is being considered to build 6 ha of new greenhouses heating by geothermal energy. The greenhouses are heated between 1500 and 2000 h per year by using geothermal energy [76].

2.4. Wind energy in agriculture

The biggest share of global wind energy capacity is held by Europe at 72%. Turkey had a share of 0.11% in Europe's installed capacity in 2001. Indeed, the wind energy potential is high in Turkey though commercial wind energy is new. Turkey's first wind farm was commissioned in February 1998, having a capacity of 1.5 MW. The capacity is likely to grow rapidly, as plans have been submitted for an additional 600 MW [77]. In 2008, 847 GWh of electricity generation has been recorded [78].

Wind energy is a natural energy and basically depends on geographical location. Usage of wind energy is mostly to generate electricity, to reveal the water sources, to irrigate fields and to grind some of the crops. Especially, electric generation from wind energy is kind of a recent activity. However, the vast majority of wind turbines built in the past have been used for non-electrical applications. Water pumping and grain grinding are classical applications of wind power. Wind turbines have been used for many centuries

by a number of cultures for watering livestock, land drainage, irrigation, salt production and supplying household needs [79].

For agricultural activities, wind turbines are designed as 2, 3 or 4 winged. In recently years, wings are made of fiberglass material. And also sometimes wood or aluminum materials can be used.

Wind turbines are mostly designed with direct current generator. Wind energy has a changeable characteristic, so that to eliminate this specification, in these systems, electricity is stored. In this way, accumulator batteries are used to store the electricity in most applications, so that, yield of energy is increased. This application uses accumulator batteries to store more electric energy.

2.4.1. *Use of wind energy in greenhouse*

In Turkey's conditions, greenhouses have a huge portion in agricultural applications. Lots of vegetables and fruits can be grown up in greenhouses according to the periodic temperature of seasons. All this time, greenhouses need energy both through day time and night.

Heating system's energy requirement is more than the other applications. To heat a greenhouse, different renewable energies can be used, as also wind energy. A wind turbine is built up close to greenhouse and heat pomp can be added to system, and gained energy can be used for lots of application in greenhouse, such as, heating, lighting, to run automatic systems and cooling. Electric energy must be stored in accumulators to use this energy when wind is non-existent [80].

2.4.2. *Irrigation by wind energy*

Irrigation systems with wind energy use mostly modern turbines, drains water from deep soil and transports water to the land with the energy from turbines. Water pumping systems are poly-winged, high moment capability and able to work with water pump. In these systems, 3–5 kW powered turbines are used [81]. At present in Turkey, 94 GW powered formed systems are being used. These systems are grown in number by studies and supports. 2% of that energy is used for lands to irrigate [82].

Wind energy's characteristic is a variable; because of that, it is needed to store the water if wind is nonexistent. For this aim, natural or artificial pools and depots are used for the lands which needs to be irrigated. In this way, land can be watered easily [83].

Water pumping systems with wind energy have some advantages: (i) wind is a natural source, (ii) it is renewable, (iii) it is gratis, and (iv) it is a basic system and so does not need more maintenance and repair and is cheaper.

Both low- and high-speed turbines can be used. Poly-winged turbines mostly run in low speed and usually single-moving pump is used. If the predicted water amount is not attained, water storage firms help to supply water. On the other hand, if water amount is more than expected, wind turbines are run to remove surplus water.

In Turkey, in some cities, there are irrigation systems which use wind energy as a source. One of these is in Edirne, and does not have a capability to generate electricity, but uses direct motion power of wind and runs piston pump and irrigates a land measure of about 3000 m^2. Another sample is in Muğla-Bodrum, which generates electricity and uses this energy for drip watering technique [83].

2.4.3. *Grinding by wind energy*

The first corn-grinding wind turbine was built in Holland in 1439. This application was so common that all wind turbines were often called windmills even when they actually pumped water or performed some other function [84].

In most countries, people used windmills to grind wheat and corn, to pump water, and to cut wood at sawmills. Today, people occasionally use windmills to grind grain and pump water, but they also use modern wind turbines to make electricity [85].

It is still used to grind wheat, corn and barley, but modern technologies replace classical windmill grindings.

Table 12
Hydropower facilities classification by power ranges [87,88].

Power	Classification
P > 100 MW	Major hydraulic facilities
100 > P > 20 MW	Middle scaled hydraulic facilities
20 > P > 1 MW	Minor hydraulic facilities
1000 kW > P > 20 kW	Mini hydraulic facilities
20 kW > P	Micro-hydraulic facilities

2.5. *Hydropower*

Hydropower is the most available energy form in the nature. But also, hydropower is one of the most commonly used energy in the world [86]. Water is the basic and absolutely the most important source for the humanity and the world. It needs to be collected carefully, stored and managed. Unfortunately, depending on global warming, water source and amounts are decreasing critically. Water, the life's keystone, is in danger because of misusage.

Hydroelectricity is generated by hydraulic power. Water's potential energy firstly converts to mechanical, then electricity energy. While in 2003, hydropower had provided 19% of world's energy need, in 2005, this proportion raised up to 69%.

Hydraulic facilities are classified by their capacity as shown in Table 12.

There are lots of ways to use hydropower. These are:

- Water-wheels, the most common used mills
- The gained hydroelectricity energy from barrages
- Energy from rivers' and oceans' kinetic energies
- Vortex power, the energy by forming gulf
- Tide power, dependent on tide in horizontal plane
- Wave power, forms by waves in open seas and oceans
- Osmotic power, the energy, gained by flow rate between lakes and oceans
- Flow power, the energy gained by flows through seas
- Ocean thermal energy conversion, the energy, gained by using the temperature differences between deep and shallow of the ocean [87,88].

Turkey has a total gross hydropower potential of 433 GWh/year, but only 125 GWh/year of the total hydroelectric potential of Turkey can be economically used. By the commissioning of new hydropower plants, which are under construction, 36% of the economically usable potential of the country would be tapped [89].

Turkey's hydropower potential is really high. Approximately 5500 MW of hydropower capacity is under construction, the largest schemes being Deriner Dam in the north of the country (680 MW) and Berke Dam in the southeast (520 MW). In Turkey, 566 hydropower projects by DSI (State Hydraulic Works) have been identified for development in total, 130 are already in operation, and 405 (with a capacity of 19,951 MW) are planned [89].

Hydropower often supports other essential water services, such as irrigation, flood control and drinking water supplies. It facilitates the equitable sharing of a common vital resource [90]. For example, in 2009, irrigation field has been increased up to 2,690,035 ha and in 2010 it is 2,769,018 ha. Fig. 12 shows the irrigation field augmentation between year 1995 and 2010 [91].

The Southeastern Anatolia Project (GAP) originally planned by the State Hydraulic Works is a combination of 12 major projects primarily for irrigation and hydroelectric generation. The project

Table 13
Dams and hydroelectric power plants.

Province	Name of the dam	Province	Name of the dam
Kahramanmaraş	Kısık Hydroelectric power plant (HEPP)	İçel	Lamas-Gökler and Berdan dam and HEPP
Kayseri	Çamlıca-I HEPP	Sakarya	Hasanlar dam and HEPP
Kayseri	Yamula HEPP	Gaziantep	Birecik dam and HEPP
Çanakkale	Gönen HEPP	Elazığ	Hazar-I and II
Kütahya	Dinar HEPP[a]	Malatya	Tohma HEPP[a]
Isparta	Aksu[a] and Sütçüler HEPP	Iğdır	Gaziler HEPP
Denizli	Çal HEPP[a]	Erzincan	Girlevik-II–Mercan[a]
Muğla	Fethiye HEPP[a]	Sivas	Ahiköy-I and II[a]
Kahramanmaraş	Suçatı HEPP		

[a] The dams which are also used to irrigate, 2007.

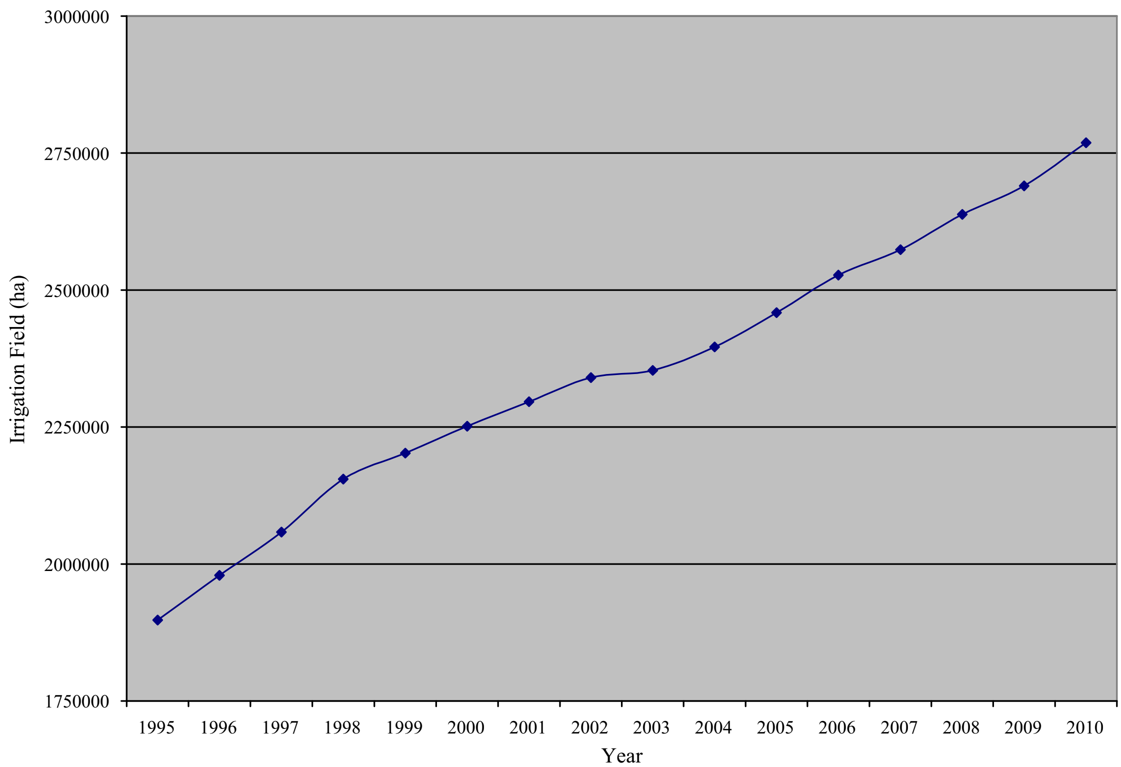

Fig. 12. Irrigation field augmentations between years 1995 and 2010.

includes the construction of 22 dams and 19 hydroelectric power plants on the Euphrates and the Tigris rivers and their tributaries. It is planned that upon completion, over 1.8 million ha of land will be irrigated and 27 billion kWh hydroelectric energy will be generated annually [90].

Most regions of Turkey, especially in Mersin, Denizli, Eastern Anatolia and Black Sea, micro- and mini-facilities exist. These mini- and micro-facilities' advantages are that they do not need huge water sources and high costs; also, it is an easier way to carry the water to the agricultural irrigation fields because these systems are close to existent tributary [92].

Table 14
Renewables and prices per energy kind.

Renewable energy	Price ($-cent)
Hydroelectricity	7.3
Wind energy	7.3
Geothermal energy	10.5
Biomass energy	13.3
Solar energy	13.3

Table 13 shows existing dams and hydroelectric power plants, also marked that are the dams which are used to irrigate [93].

3. Conclusions

Turkey has a large scale of renewable energies, although less fossil energy sources. Every year, Turkey imports energy from abroad and it costs really high. This imported energy is mostly used for transportation, generating electricity and heating. Also, agricultural activities need energy to perform production. Based on Turkey's renewables potential, using them as energy resources on agriculture would help economically, socially and environmentally. Agriculture in Turkey plays very important role in sustainability. Production, importation and exportation rates in agricultural production keep a huge space on Turkish trades and markets. 24 million people are engaged in agriculture and most of them live in rural areas. Using renewables in agriculture is especially important for them.

Turkey has the potential for 977,000 TWh/year of solar energy, 800,000 Mtoe/year of hydropower, 433 TWh/year of wind energy, 35,000 MW of geothermal energy and 31,600 Mtoe/year of biomass

energy. Energy research and developmental studies are carried out by universities, institutes, agencies, sensible organizations and governmental institutions. With these studies, using renewables in agriculture and other applications would be charming and become widespread. Also, according to the last legislated law (08.01.2011 dated Official Journal, Law No. 6094, Accepted Date: 29.12.2010) renewable energies and utilizations are supported by the government. Price of electricity from renewables has been decided as shown in Table 14 [94].

Also, until the date 31.12.2015, for the first 10 years of new and existing facilities, 85% discount is validated on cost of rent, easement and certificate of occupancy. For national park, natural park, natural monument, nature reserve area, protection forest and wildlife protection areas, the permission to build renewable energy facilities is going to be assigned relevant Ministry [94].

All these potential of renewables and new legal regulations are the steps on future renewable facilities and they will be improved and developed year by year with new supports and entrepreneurs on regional sector of renewables.

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